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DIODE

STEP STRESS TESTING PROGRAM

MSFC/NASA CONTRACT NUMBER
NAS8-31944

FINAL REPORT
FOR
JANTX1N3031B

FEBRUARY 1979

Prepared
For

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FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transisters, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the zener diode JANTX1N3031B manufactured by Siemens and Motorola.

A total of 48 samples from each manufacturer was submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-Speed Computer-Controlled Tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all the test devices during the power/temperature stress conditions. The voltage was set by V_Z and the current was varied in order to comply with the specified power rating for the device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were subjected to no less than 90% of MRP. See Figure 1

for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The zener diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power (MRP) for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed

on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Siemens. The Siemens sample lot completed 550 hours of Group I Testing at which point over 50% of the lot had failed. The lot continued processing another 450 hours and accumulated two more failures. The first failures occurred 50 hours into the 100% MRP step. Serial numbers 5066, 5067, 5068, 5069, 5070, 5071, 5072, 5073, 5074, 5075, 5076, 5077 and 5080 failed the maximum ^{B}V limit. The last failures occurred 150 hours into the 100% MRP step. Serial numbers 5063 and 5065 failed the minimum ^{B}V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for ^{I}R changed 6.828nA from an initial mean of 422.5pA to a final mean of 7.250nA.
2) The mean value for ^{B}V changed 10.00mV from an initial mean of 28.98V to a final mean of 28.99V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Motorola. The Motorola sample lot completed the entire 2500 hours of Group I Testing with only one catastrophic failure. The failure occurred 250 hours into the 175% MRP step. Serial number 5121 failed the maximum ^{B}V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 8.313nA from an initial mean of 2.997nA to a final mean of 11.31nA.

2) The mean value for ^{B}V changed 190.0mV from an initial mean of 29.67V to a final mean of 29.86V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I. Table 4 outlines the results of Group I - Power Stress Process for each of the electrical parameters and all measurement points for both Siemens and Motorola.

3.2 Group II - Temperature Stress I

3.2.1 Siemens. The Siemens sample lot completed 1120 hours of Group II Testing before the lot was stopped due to a failure rate exceeding 50% of the lot. The first failure occurred 160 hours into the 175°C-temperature step. Serial number 5084 failed the maximum ^{B}V limit. The next failures occurred 160 hours into the 200°C-temperature step. Serial numbers 5089 and 5091 failed the minimum ^{B}V limit. The last failures occurred 160 hours into the 225°C-temperature step. Serial numbers 5085, 5092, 5093 and 5096 failed because of excessive I_R leakage. Serial numbers 5086, 5087, 5088 and 5090 failed the maximum ^{B}V limit. Serial numbers 5083, 5094 and 5095 failed the minimum ^{B}V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 333.9μA from an initial mean of 2.266nA to

a final mean of 133.9μA.

2) The mean value for ^{B}V changed 30.00mV from an initial mean of 28.98V to a final mean of 29.01V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Motorola. The Motorola sample lot completed 1440 hours of Group II Testing before the lot was stopped due to a failure rate of more than 50% of the lot. The first failures occurred 160 hours into the 250°C-temperature step. Serial numbers 5136, 5137, 5138, 5142 and 5145 failed the minimum ^{B}V limit. The last failures occurred 160 hours into the 275°C-temperature step. Serial numbers 5133, 5140, 5141, 5144 and 5147 failed due to excessive ^{I}R leakage. Serial numbers 5134, 5043 and 5148 failed the minimum ^{B}V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for ^{I}R changed 304.6mA from an initial mean of 2.125nA to a final mean of 304.6mA.

2) The mean value for ^{B}V changed 110.0mV from an initial mean of 29.47V to a final mean of 29.58V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 of this report outlines the results of Group II - Temperature Stress I Testing, for each of the electrical parameters and all of the measurement points pertaining to both Siemens and Motorola.

3.3 Group III - Temperature Stress II

3.3.1 Siemens. The Siemens sample lot completed 80 hours of Group III Testing before the lot was stopped because more than 50% of the devices had failed. The first failure occurred 16 hours into the 175°C-temperature step. Serial number 5101 failed the maximum ^{B}V limit. The next failures occurred 16 hours into the 225°C-temperature step. Serial numbers 5102, 5015 and 5108 failed the minimum ^{B}V limit. Serial number 5111 failed the minimum ^{B}V limit. The final failures occurred 16 hours into the 250°C-temperature step. Serial numbers 5098, 5099, 5103, 5106, 5107, 5109, 5110 and 5112 failed the maximum ^{B}V limits. Serial numbers 5097 and 5104 failed the minimum ^{B}V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for ^{I}R changed 2.733μA from an initial mean of 366.9pA to a final mean of 2.733μA.
2) The mean value for ^{B}V changed 8.32V from an initial mean of 29.11V to a final mean of 37.43V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Motorola. The Motorola sample lot completed the entire 112-hour Group III Testing with no failures. Typical characteristics of this sample lot's performance were:

1) The mean value for ^{I}R changed 15.20nA from an initial mean of 25.57nA to a final mean of 10.37nA.

2) The mean value for ^{B}V changed 40.00mV from an initial mean of 29.54V to a final mean of 29.58V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II Testing, for each of the electrical parameters and all of the measurement points for both Siemens and Motorola.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 were used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in Figures 3 and 5, respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

The Motorola diodes performed much better than the Siemens in all three of the stress groups. Motorola experienced only one failure in the Group I Testing and no failures in the Group III Testing. Although Motorola's sample lot was stopped in the Grpup II Testing, note that it was not stopped until 320 hours after the Siemens lot. Both the Siemens and Motorola devices failed due to exposure to excessive temperatures which, in many cases, melted the metal on the die connections. The electrical test results suggest that the long dwell time of the molten metal has caused the metal to alloy with the silicon dice, thus shorting out their junctions. Some of the Siemens devices also had significant electrical leakage of the glass in the glass-to-metal seal. The glass was conductive when probed either internally or externally, with the internal conductivity being somewhat greater.

A plot showing cumulative failure distribution of Group II was drawn for the Siemens sample lot (Figures 2 and 3) but due to an early excessive freak failure rate in the Group III Testing, a complete plot for Group III could not be drawn. A complete plot could not be drawn for the Motorola sample lot (Figures 4 and 5) due to an absence of Group III failure points.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated main failure point. The regression line was calculated using the least square method.

the least squares method.

The activation energy was calculated from the formula:

$$E = \left[\ell n \left(\frac{t_1}{t_2}\right)\right]\left[\frac{8.63 \times 10^{-5}\ eV/^{\circ}K}{\left(\frac{1}{T_1+273}\right) - \left(\frac{1}{T_2+273}\right)}\right] eV$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in $^{\circ}C$ of 16% failure for Group II.

T_2 = temperature in $^{\circ}C$ of 16% failure for Group III.

NOTE:

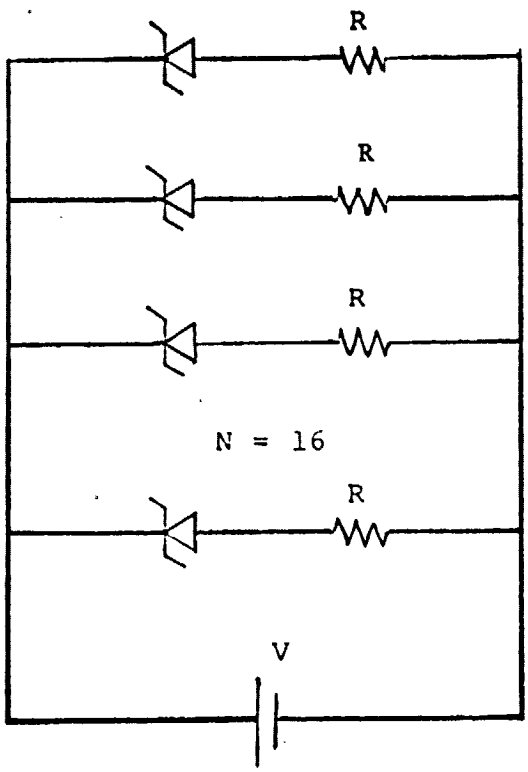
* Conditions for failure:

A) Open or short

B) Leakage exceeds the maximum limit by 100 times.

C) Other parameters exceed MIL limits by 50% or more.

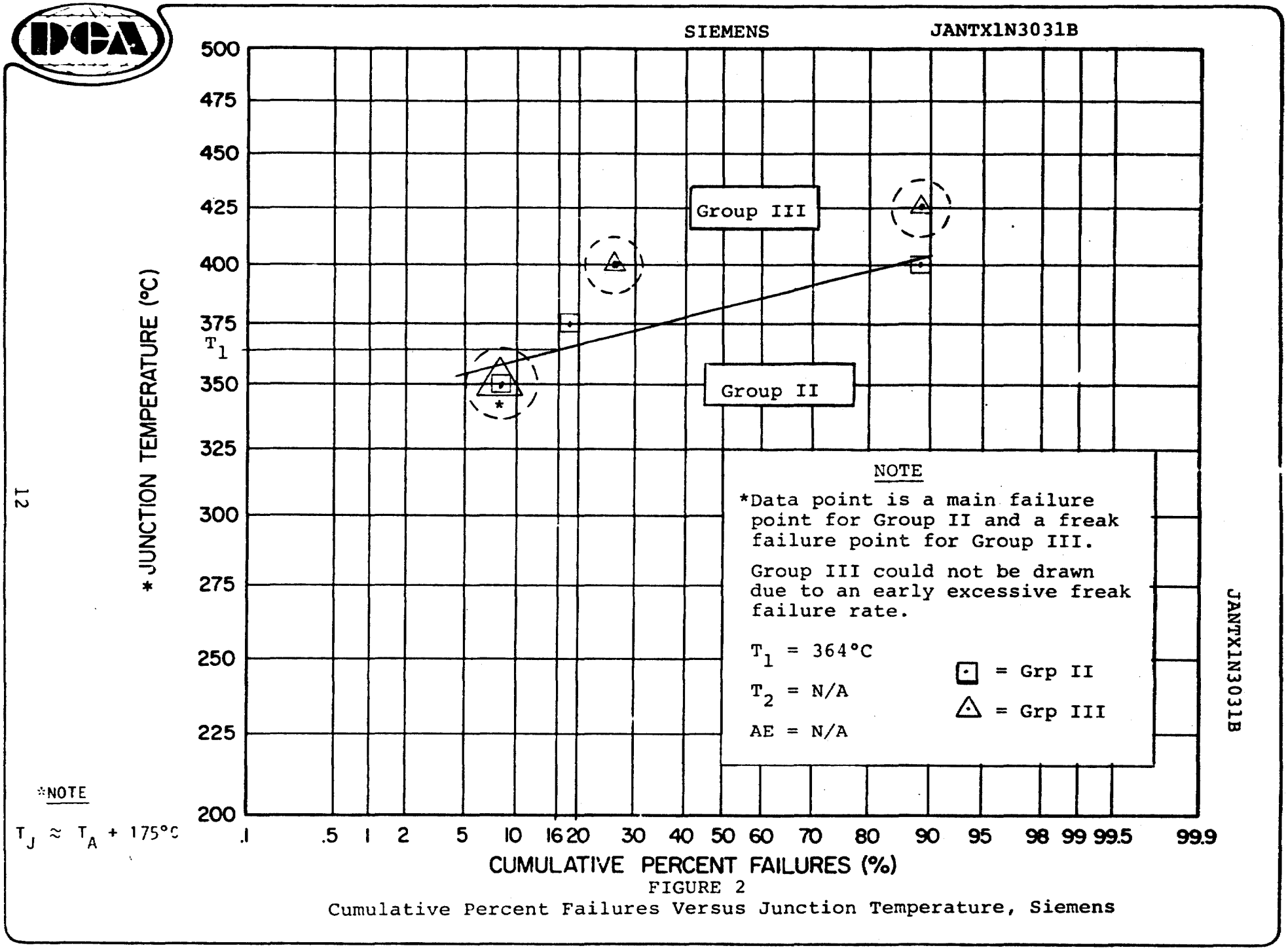
ZENER DIODES



$R = VZ \div 1.75\ IZ_{MAX} \pm 50\%$

$P_d = VZ^2 \div R$

FIGURE 1
Temperature/Stress Circuit
for JANTX1N3031B



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2

Cumulative Percent Failures Versus Junction Temperature, Siemens

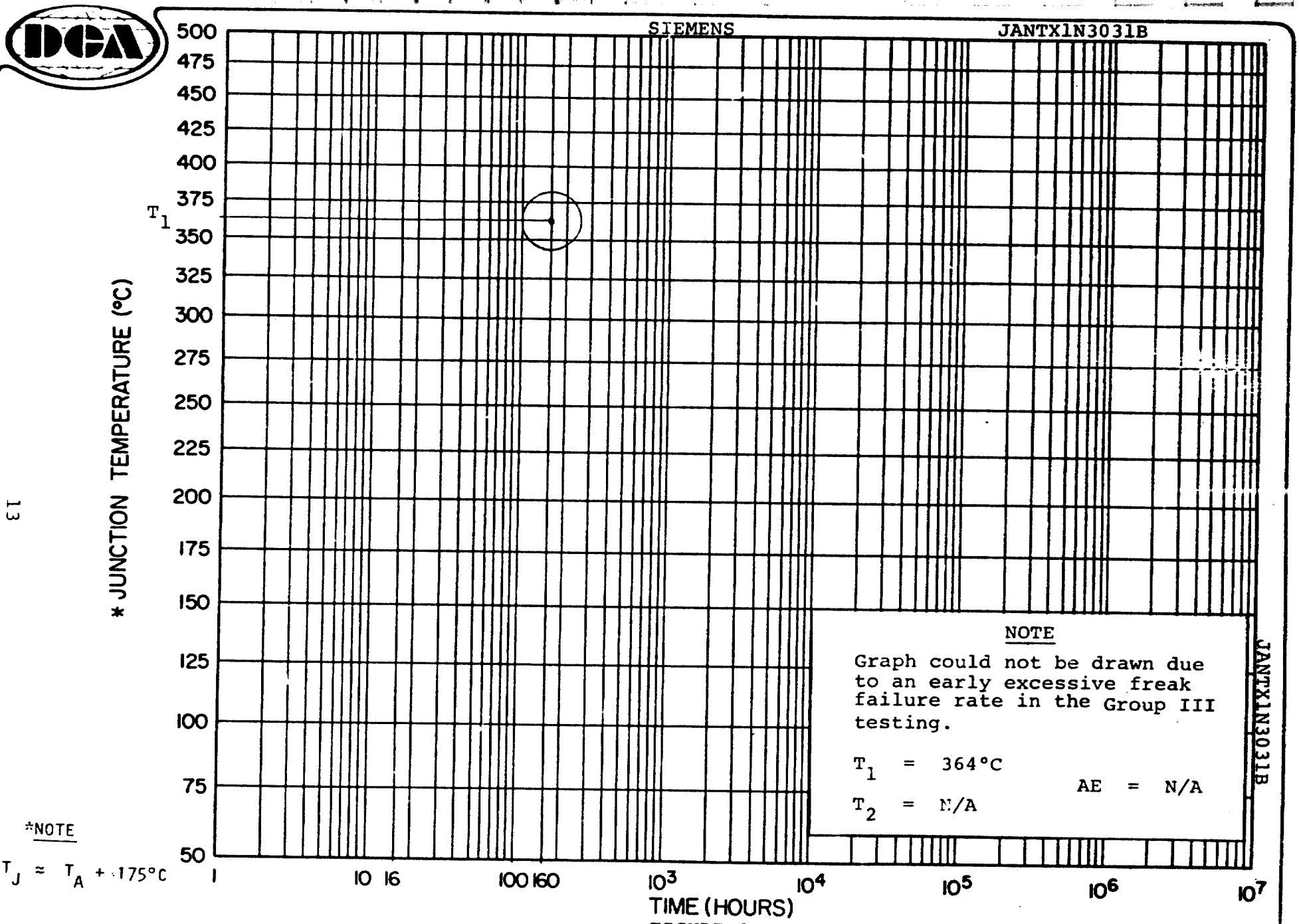
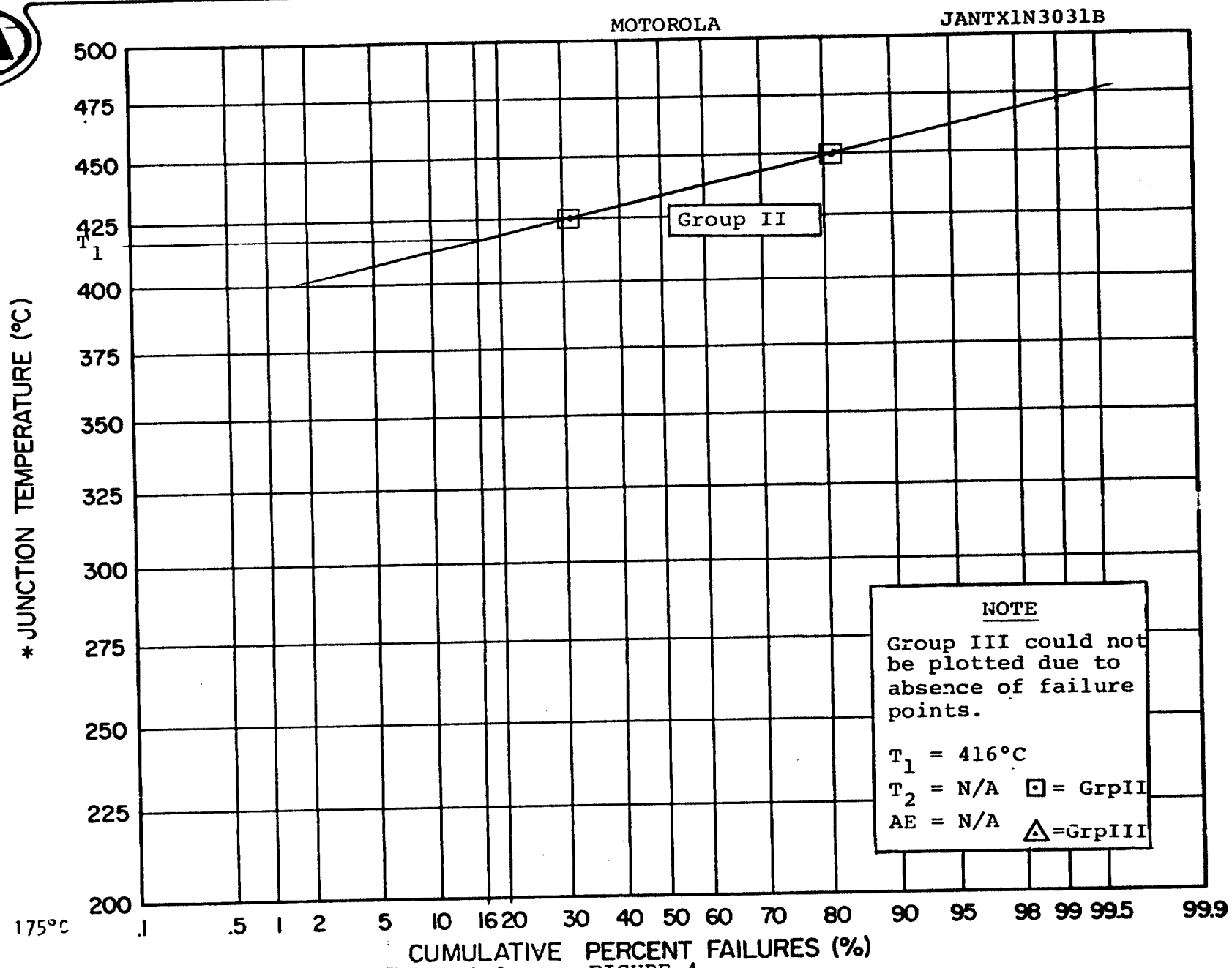


FIGURE 3
Time Steps Versus Junction Temperature, Siemens

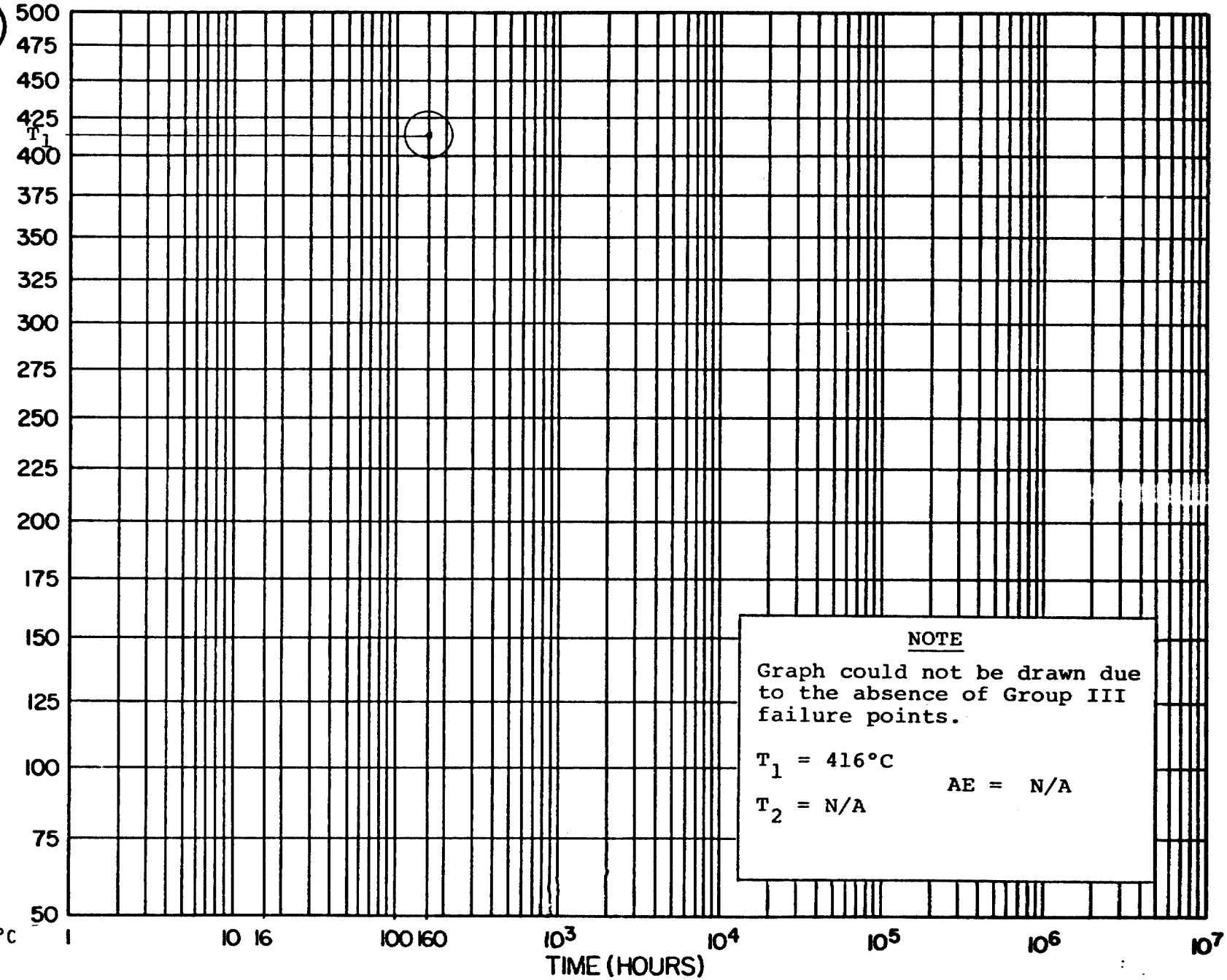


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, Motorola

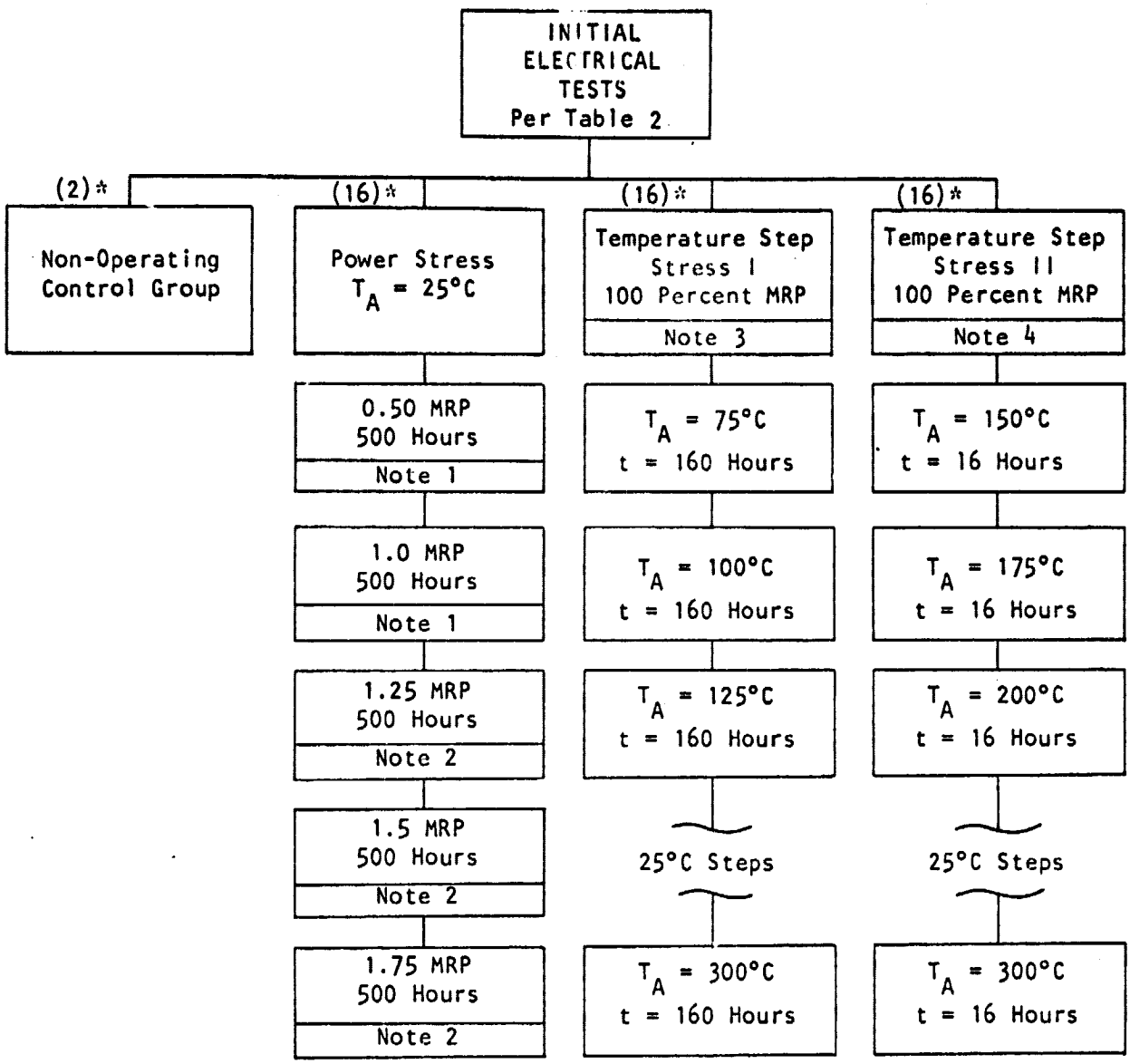


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 5
Time Steps Versus Junction Temperature, Motorola

TABLE 1
TEST FLOW DIAGRAM



*Quantity per manufacturer (SIEMENS AND MOTOROLA)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were made at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_R	V_R = 22.8V	-	10		1000	µA
B_V	I_Z = 8.5mA	28.5	31.5	14.25	47.25	V

NOTES:
1/ In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

V_Z = 30V	
I_Z	Percent P_D
16.65mA	50
33.3mA	100
41.62mA	125
49.95mA	150
58.27mA	175

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I — POWER STRESS DATA SUMMARY

PARAMETER	I_R = 10μA(MAX)		B_V=28.5V(MIN) 31.5V(MAX)					
CONDITIONS AND LIMIT	V_R = 22.8V		I_Z = 8.5mA					
IDENTIFICATION	SIE	MOT	SIE	MOT				
INITIAL DATA								
MIN VALUE	60.00pA	150.0pA	28.62V	28.89V				
MAX VALUE	1.040nA	26.60nA	29.94V	31.24V				
MEAN	422.5pA	2.997nA	28.98V	29.67V				
STL DEV	287.5pA	6.419nA	340.9mV	732.3mV				
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 HRS	-29.90pA	-855.0pA	-20.00mV	-10.00mV				
150 HRS	14.40pA	-1.071nA	-10.00mV	-10.00mV				
250 HRS	3.700pA	-172.0pA	-20.00mV	-10.00mV				
500 HRS	18.10pA	926.0pA	-80.00mV	-100.0mV				
100% POWER								
550 HRS	320.8pA	386.0pA	*340mV	-60.00mV				
650 HRS	-102.5pA	1.007nA	*-80.00mV	-60.00mV				
750 HRS	727.5pA	259.0pA	0.000V	-20.00mV				
1000 HRS	6.828nA	60.00pA	-10.00mV	10.00mV				
125% POWER								
1010 HRS	JOB STOPPED	720.0pA	JOB STOPPED	-60.00mV				
1025 HRS		462.0pA		-80.00mV				
1050 HRS		1.620nA		-70.00mV				
1150 HRS		-312.0pA		-60.00mV				
1250 HRS		-10.00pA		-70.00mV				
1500 HRS		-326.0pA		-80.00mV				

(continued on second sheet)

TABLE 4 (Cont'd)

(continued from first sheet) GROUP I — POWER STRESS DATA SUMMARY

PARAMETER	I_R =10μA(MAX)		B_V=28.5V(MIN) 31.5V(MAX)					
CONDITIONS AND LIMITS	V_R = 22.8V		I_Z = 8.5mA					
IDENTIFICATION	SIE	MOT	SIE	MOT				
INITIAL DATA								
MIN VALUE	60.00pA	150.0pA	28.62V	28.89V				
MAX VALUE	1.040nA	26.60nA	29.94V	31.24V				
MEAN	422.5pA	2.997nA	28.98V	29.67V				
STD DEV	287.5pA	6.419nA	340.9mV	732.3mV				
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 HRS	JOB STOPPED	-553.0pA	JOB STOPPED	-50.00mV				
1525 HRS		-125.0pA		-20.00mV				
1550 HRS		-601.0pA		-30.00mV				
1640 HRS		-399.0pA		-40.00mV				
1750 HRS		8.423nA		-20.00mV				
2000 HRS		6.567nA		-30.00mV				
175% POWER								
2010 HRS		1.855nA		-30.00mV				
2025 HRS		2.330nA		-20.00mV				
2050 HRS		486.0pA		-60.00mV				
2150 HRS		1.632nA		-20.00mV				
2250 HRS		1.990nA		80.00mV				
2500 HRS		8.313nA		190.0mV				
FINAL DATA								
MIN VALUE	7.250nA	840.0pA	28.99V	28.91V				
MAX VALUE	7.250nA	44.60nA	28.99V	31.25V				
MEAN	7.250nA	11.31nA	28.99V	29.86V				
STD DEV	0.000nA	12.73nA	0.000V	733.8mV				

* NOTE: Catastrophic reject(s) removed from data after this point

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	I_R = 10μA(MAX)		B_V=28.5V(MIN) 31.5V(MAX)					
CONDITIONS AND LIMITS	V_R = 22.8V		I_Z = 8.5mA					
IDENTIFICATION	SIE	MOT	SIE	MOT				
INITIAL DATA								
MIN VALUE	240.0pA	330.0pA	28.72V	28.64V				
MAX VALUE	30.60nA	10.90nA	29.63V	31.27V				
MEAN	2.266nA	2.125nA	28.98V	29.47V				
STD DEV	7.317nA	2.597nA	235.4mV	639.0mV				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP (T_A)								
160 / 75°C	-2.019nA	-274.0pA	-60.00mV	-20.00mV				
320 / 100°C	-1.828nA	2.941nA	-30.00mV	-10.00mV				
480 / 125°C	-1.762nA	7.444nA	-30.00mV	-10.00mV				
640 / 150°C	-1.715nA	8.935nA	-40.00mV	-110.0mV				
800 / 175°C	-1.646nA	7.271nA	20.00mV	-20.00mV				
960 / 200°C	*102.0μA	4.961nA	50.00mV	-50.00mV				
1120 / 225°C	*333.9μA	2.539nA	30.00mV	50.00mV				
1280 / 250°C	JOB STOPPED	3.478nA	JOB STOPPED	180.0mV				
1440 / 275°C	↓ ↓	*304.6mA	↓ ↓	110.0mV				
1600 / 300°C		JOB STOPPED		JOB STOPPED				
FINAL DATA								
FINAL TEMP	225°C	275°C	225°C	275°C				
MIN VALUE	54.60nA	14.00nA	28.94V	28.62V				
MAX VALUE	999.0μA	990.0mA	29.07V	30.08V				
MEAN	333.9μA	304.6mA	29.01V	29.58V				
STD DEV	444.9μA	426.3mA	65.00mV	455.2mV				

* NOTE: Catastrophic reject(s) removed from data after this point

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	I_R = 10μA(MAX)		B_V = 28.5V(MIN) 31.5V(MAX)					
CONDITIONS AND LIMITS	V_R = 22.8V		I_Z = 8.5mA					
IDENTIFICATION	SIE	MOT	SIE	MOT				
INITIAL DATA								
MIN VALUE	200.0pA	290.0pA	26.60V	28.87V				
MAX VALUE	620.0pA	380.0nA	29.72V	30.75V				
MEAN	366.9pA	25.57nA	29.11V	29.54V				
STD DEV	132.5pA	94.10nA	369.6mV	597.4mV				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP(T_A)								
16 / 150°C	200.0pA	13.00nA	-20.00mV	10.00mV				
32 / 175°C	56.20pA	87.73nA	20.00mV	20.00mV				
48 / 200°C	597.1pA	49.16nA	-40.00mV	20.00mV				
64 / 225°C	*1.676μA	-1.880nA	100.0mV	20.00mV				
80 / 250°C	*2.733μA	-23.79nA	*8.32V	60.00mV				
96 / 275°C	JOB STOPPED	-22.61nA	JOB STOPPED	30.00mV				
112 / 300°C	↓ ↓	-15.20nA	↓ ↓	40.00mV				
FINAL DATA								
FINAL TEMP	250°C	300°C	250°C	300°C				
MIN VALUE	19.90nA	120.0pA	940.0mV	28.85V				
MAX VALUE	9.900μA	59.70nA	47.25V	31.13V				
MEAN	2.733μA	10.37nA	37.43V	29.58V				
STD DEV	4.015μA	13.67nA	18.55V	636.5mV				

* NOTE: Catastrophic reject(s) removed from data after this point

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			SIE	MOT	SIE	MOT	SIE	MOT
I_R	-	10	μA		+.00097	+.00125	*+62.270	*+33844.4	*+.88197	+.01234
B_V	28.5	31.5	V		+.01500 *	-.02462	-.00857	+.01222	*+1.6760	+.02857

* NOTE: Catastrophic reject(s) removed from data after this point

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N3031B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
100% 50 hr.	13	A	0	–
100 hr.	2	B	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
125% 10 hr.	JOB STOPPED		0	–
15 hr.			0	–
25 hr.			0	–
100 hr.			0	–
100 hr.			0	–
250 hr.			0	–
150% 10 hr.			0	–
15 hr.			0	–
25 hr.			0	–
100 hr.			0	–
100 hr.			0	–
250 hr.			0	–
175% 10 hr.			0	–
15 hr.			0	–
25 hr.			0	–
100 hr.			0	–
100 hr.			1	A
250 hr.			0	–

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	–	0	–
100° C	0	–	0	–
125°C	0	–	0	–
150°C	0	–	0	–
175°C	1	A	0	–
200°C	2	B	0	–
225°C	4 / 3	A / B	0	–
250°C	JOB STOPPED		5	B
275°C			3 / 5	B / C
300°C			JOB STOPPED	

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	–	0	–
175°C	1	A	0	–
200°C	0	–	0	–
225°C	3 / 1	A / B	0	–
250°C	8 / 2	A / B	0	–
275°C	JOB STOPPED		0	–
300°C			0	–

MFR "A" - SIEMENS

MFR "B" - MOTOROLA

NOTES: A - B_V > 47.25V

B - B_V < 14.25

C - I_R > 1000μA

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N3031B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
100% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
125% 10 hr.	JOB STOPPED		0	–
15 hr.	↓	↓	0	–
25 hr.			0	–
100 hr.			0	–
100 hr.			0	–
250 hr.			0	–
150% 10 hr.			0	–
15 hr.			0	–
25 hr.			0	–
100 hr.			0	–
100 hr.			0	–
250 hr.			0	–
175% 10 hr.			0	–
15 hr.			0	–
25 hr.			0	–
100 hr.			0	–
100 hr.			0	–
250 hr.	↓	↓	0	–

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	–	0	–
100° C	0	–	0	–
125°C	0	–	0	–
150°C	0	–	0	–
175°C	0	–	0	–
200°C	6	A	0	–
225°C	0	–	0	–
250°C	JOB STOPPED		0	–
275°C	↓	↓	1	A
300°C	↓	↓	JOB STOPPED	

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	–	0	–
175°C	0	–	0	–
200°C	0	–	0	–
225°C	1	A	0	–
250°C	1	B	0	–
275°C	JOB STOPPED		0	–
300°C	↓	↓	0	–

MFR "A" - SIEMENS

MFR "B" - MOTOROLA

NOTES: A - I_R limit failure

B - B_V maximum limit failure

APPENDIX A

FAILURE ANALYSIS

TEMPERATURE STRESS I

FAILURE ANALYSIS

Date 27 November 1978

J/N 2CN242-35B **P/N** 1N3031B **MFR** SIEMENS

End points: 14.25-47.25V
End point: 1.0mA Max.

S/N	PIV -volts- @ 8.5mA	I_R @ 22.8V.dc	V_F @ ___dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
5083	1.8V (R)	∞		15 (225°C 1120 Hrs. Tot)	B_V
5084	*26.5V (S) @ 50μA	∞		11 (175°C 800 Hrs. Tot)	B_V
5096	3.0V (R)	∞		15 (225°C 1120 Hrs. Tot)	I_R
	* Internally	probed - internal	lead was open.		

There is significant electrical leakage across the glass-to-metal seals on S/N 5083 and 5084.

INTERNAL VISUAL INSPECTION

S/N 5083 has a detached internal lead and die.

S/N 5084 has a detached internal lead (see Figure A-1).

S/N 5096 has a detached internal lead.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

FAILURE ANALYSIS

(TEMPERATURE STRESS I)

Date 27 November 1978

J/N 2CN242-35[illegible] **P/N** 1N3031B **MFR** MOTOROLA

End points: 14.25-47.25V
End point: 1.0mA Max.

S/N	PIV -volts- 8.5mA	I_R @ 22.8V.dc	V_F @ ___dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
5136	0.3V (R)	∞		17 (250°C 1280 Hrs. Tot)	B_V
5140	0.3V (R)	∞		19 (275°C 1440 Hrs. Tot)	I_R
5142	0.3V (R)	∞		17 (250°C 1280 Hrs. Tot)	B_V

INTERNAL VISUAL INSPECTION

S/N 5036 has a short across the die outer margin (see Figure A-2).

S/N 5140 has metal flow from the top of the die to the contact disc (see Figure A-3).

S/N 5042 has a detached internal wire where it contacts the top of the die. The metal has flowed upwards along the wire.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

CONCLUSION

All the samples except Siemens S/N 5084 were making electrical contact when received for analysis. However, the internal bonding material melted and flowed away from the dice on all the Siemens samples and Motorola S/N 5142, causing them to fall apart when delidded.

All the Siemens and Motorola devices failed due to the melting of the bonding material at the die connections caused by excessive temperatures. The molten metal shorted out the silicon die on two of the Motorola parts. The electrical test results on the remaining parts suggests that the long dwell time of the molten metal has caused it to alloy with the silicon dice, thus shorting out their junctions.

Serial numbers 5083 and 5084 of the Siemens samples also had significant electrical leakage of the glass in the glass-to-metal seal. These samples exhibit resistances of 1.6×10^5, and 6.7×10^7 ohms, respectively. The glass is conductive when probed either internally or externally, with the internal conductivity being somewhat greater.

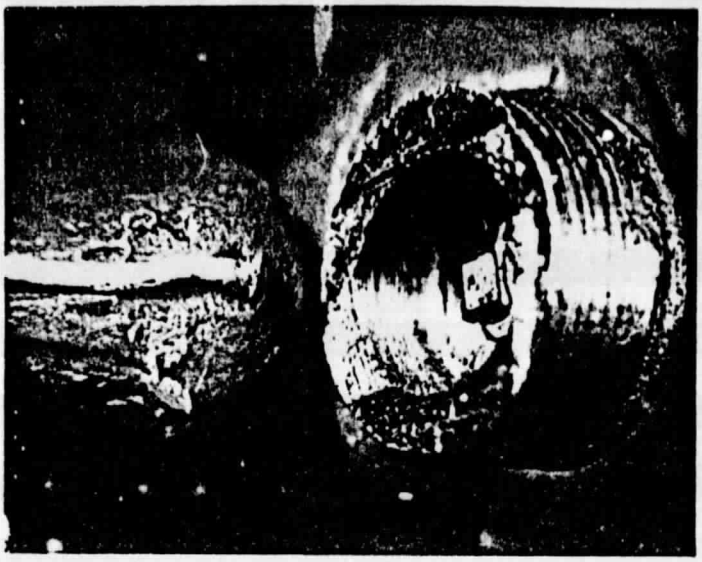


FIGURE A-1
S/N 5084, Typical Siemens Internal Appearance
Showing Detached Top Contact, 8X.

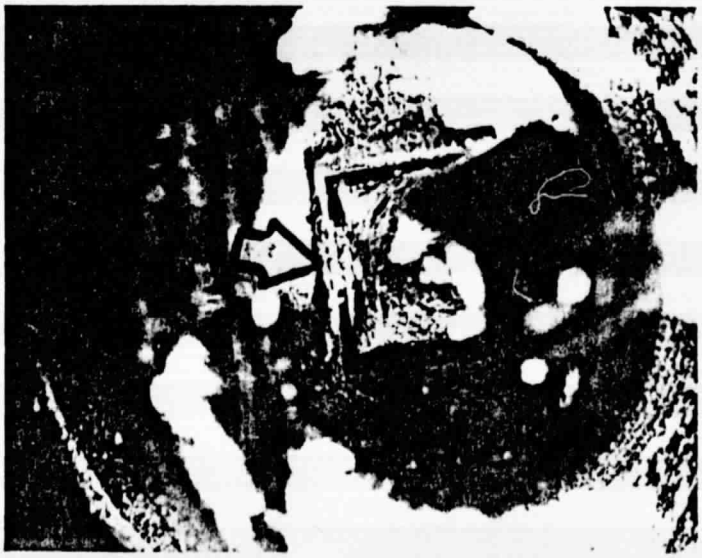


FIGURE A-2
S/N 5136, Motorola Sample, 20X.
The arrow indicates a bonding material short
which bridges the top and bottom die contacts.

FIGURE A-3
S/N 5140, Motorola Sample Indicating Metal
Flow Shorting the Silicon Die, 31X.

APPENDIX B

FAILURE ANALYSIS

TEMPERATURE STRESS II

FAILURE ANALYSIS

Date 15 May 1978

J/N 2CN242-35C P/N 1N3031B MFR SIEMENS

Limit:
28.5-31.5 150μA Max.

S/N	PIV -volts-	I_R @ 22.8V dc	V_F @ ___ dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
5107	28.8	-open- 120μA	(internally	08 (225°C probed)	B_V
5108	27.8	-open- <0.2μA	(internally	08 (250°C probed)	CAT

INTERNAL VISUAL INSPECTION

S/N 5107 has a detached internal lead. About one-third of the nickel plating is missing from the die (see Figure B-1).

CONCLUSIONS

S/N 5107 failed due to exposure to temperatures above the melting point of the bonding material, which resulted in disconnection of the lead.

S/N 5108 exhibited an electrical open as received, but makes good contact when connection is made through the internal lead wire. This indicates that the open was between the internal wire and the external lead.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

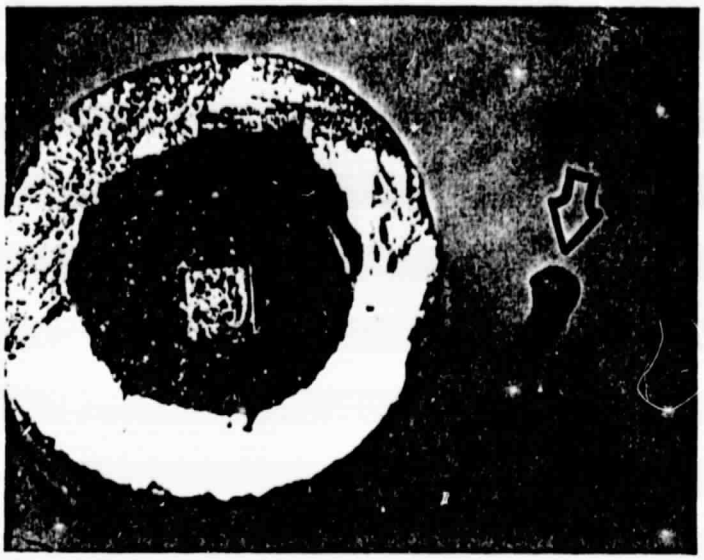


FIGURE B-1
S/N 5107, Siemens Device, 10X.
Arrows indicate silicon die with partial nickel peeling and detached internal lead wire.